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IS : 7391 (Part I) - 1974
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Indian Standard
SPECIFICATION FOR COTTON COVERED COPPER CONDUCTORS

PART I ROUND CONDUCTORS

(Second Reprint FEBRUARY 1997)

(Incorporating Amendments No. 1 and 2)

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
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SPECIFICATION FOR COTTON COVERED COPPER CONDUCTORS

PART I ROUND CONDUCTORS

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Indian Standard

SPECIFICATION FOR COTTON COVERED COPPER CONDUCTORS

PART I ROUND CONDUCTORS

0. FOREWORD

0.1 This Indian Standard (Part I) was adopted by the Indian Standards Institution on 22 July 1974, after the draft finalized by the Winding Wires Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 The cotton covered round copper conductors were originally covered in IS : 450-1953 which was first revised in 1964 and is now being superseded by this standard. This standard has been lined up with the latest IEC Recommendations. To cover adequately the properties of cotton yarn, a reference has been made to IS : 3567-1966*.

0.2.1 This standard (Part I) covers cotton covered round copper conductors. Cotton covered rectangular copper conductors are covered in Part II of this standard.

0.3 In the preparation of this standard, considerable assistance has been derived from the following publications:

IEC Pub 182-1 (1964) Basic dimensions of winding wires: Part I Dimensions of conductors for round winding wires. International Electrotechnical Commission.

Doc : 71/25975 Draft British Standard specification for textile covered copper conductors, Part I Round wire (metric units). British Standards Institution.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960†. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard (Part I) covers the requirements and dimensions for round copper conductors covered with one or two layers of cotton yarn.

1.1.1 It does not apply to other types of cotton covering, such as braiding.

---

*Specification for cotton yarn for covering conductors.

†Rules for rounding off numerical values (*revised*).

1.2 The requirements of this standard are applicable to conductors having diameters 0·140 to 5·000 mm.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Wire — The insulated material as received.

2.2 Conductor — The bare metal after removal of the cotton covering.

2.3 Increase in Diameter Due to Covering — The difference between the diameter over the cotton covering and the diameter of the conductor.

2.4 Tolerance — The permissible divergence of an actual magnitude from that prescribed.

3. GRADES

3.1 The wire shall be classified into two grades as follows:

a) Single, Ordinary or Fine; and

b) Double, Ordinary or Fine.

4. GENERAL TEST CONDITIONS

4.1 Unless otherwise specified, all tests shall be carried out within a temperature range of 15 to 35°C, and a relative humidity range of 45 to 75 percent. Before measurements are made, the specimens shall be preconditioned under these atmospheric conditions for a time sufficient to allow specimens to reach stability.

4.2 The wire to be tested shall be removed from the packaging in such a way that the wire is not subjected to tension or unnecessary bends.

4.3 Before each test sufficient length of wire shall be discarded to ensure that any damaged wire is not included in the test specimens.

4.4 When no specific range of sizes is given for a test, the test is applicable to all sizes.

5. CONDUCTOR

5.1 The conductor shall be of high conductivity annealed copper having the properties given in **5.2**.

5.2 Physical Constants

5.2.1 *Coefficient of Linear Expansion* — The coefficient of linear expansion of annealed copper over a temperature range of 0 to 150°C shall be taken as 0·000 017 per degree Celsius.

5.2.2 *Density* — The density of annealed copper at a temperature of 20°C shall be taken as 8·89 g/cm^3.

5.2.3 *Resistance* — The resistance at 20°C of a conductor of annealed copper of one metre in length and of a uniform cross-sectional area of one square millimetre shall be taken as 0·017 241 ohm.

5.2.4 *'Constant Mass' Temperature Coefficient of Resistance* — At a temperature of 20°C the 'constant mass' temperature coefficient of resistance of annealed copper measured between two potential points rigidly fixed to the conductor, the metal being allowed to expand freely, shall be taken as 0·003 93 per degree Celsius.

NOTE — For any temperature t_0 above 0°C the temperature coefficient of resistance is $\frac{1}{234{\cdot}45+t_0}$.

5.3 Diameter — The diameters and tolerance on conductor diameters shall be as given in Table 1.

NOTE — The conductor shall be checked for diameter and/or resistance in the following manner:

Diameter mm	*Measurement*
Up to and including 1·000	By resistance and diameter
Over 1·000	Only by diameter

5.4 Out—of—Roundness of Conductor (Nominal Conductor Diameter Over and Including 0·071 mm) — The out-of-roundness shall be not more than 50 percent of the total value for tolerance given in Table 1.

5.5 Resistance -- *See* Note under **5.3**.

5.5.1 The resistance of the conductors at 20°C shall be as given in Table 1.

5.5.2 The resistance of the conductor shall be expressed as the dc resistance at 20°C. The method used shall provide an accuracy of 0·5 percent.

One measurement shall be made.

If the resistance R_t is measured at a temperature t other than 20°C, the resistance, R_{20} at 20°C, shall be calculated by means of the formula :

$$R_{20} = \frac{R_t}{1+0{\cdot}003\,93\,(t-20)}$$

where t is the actual temperature in °C during the measurement.

5.5.3 *Tolerance on Resistance* — The maximum and minimum permissible values of resistance shall be as given in Table 1 and are calculated by the method described in Appendix A.

5.6 *Elongation* — A sample of conductor 250 mm long between grips shall be steadily stretched at a rate not more than 300 mm/min until the conductor fractures. The elongation at fracture shall comply with the requirements of Table 1.

TABLE 1 DIMENSIONS, RESISTANCE AND ELONGATION OF COTTON COVERED CONDUCTORS

(*Clauses* 5.3, 5.4, 5.5.1, 5.5.3, 5.6 *and* 8.1)

NOMINAL CONDUCTOR DIAMETER	TOLERANCE ± t	SINGLE COTTON COVERING				DOUBLE COTTON COVERING				RESISTANCE AT 20°C			ELONGATION
		Ordinary		Fine		Ordinary		Fine					
		Overall Diameter	*Increase in Diameter*	*Overall Diameter*	*Increase in Diameter*	*Overall Diameter*	*Increase in Diameter*	*Overall Diameter*	*Increase in Diameter*				
		Max	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Nom*	*Max*	*Min*	*Min*
(1) mm	(2) mm	(3) mm	(4) mm	(5) mm	(6) mm	(7) mm	(8) mm	(9) mm	(10) mm	(11) Ω/m	(12) Ω/m	(13) Ω/m	(14) percent
0·140	0·003	0·253	0·090	0·233	0·075	0·343	0·160	0·293	0·125	1·120	1·180	1·064	18
0·160	0·003	0·273	0·090	0·253	0·075	0·363	0·160	0.313	0·125	0·857 5	0·898 3	0·819 2	19
0·180	0·003	0·293	0·090	0·273	0·075	0·383	0·160	0·333	0·125	0·677 5	0·706 8	0·649 9	20
0·200	0·003	0·313	0·090	0·293	0·075	0·403	0·160	0·353	0·125	0·548 8	0·570 6	0·528 2	21
0·224	0·003	0·337	0·090	0·317	0·075	0·427	0·160	0·377	0·125	0·437 5	0·453 4	0·422 4	21
0·250	0·004	0·364	0·100	0·354	0·083	0·474	0·180	0·424	0·140	0·351 2	0·365 9	0·337 4	22
0·280	0·004	0·404	0·100	0·384	0·083	0·504	0·180	0·454	0·140	0·280 0	0·290 7	0·269 8	22
0·315	0·004	0·439	0·100	0·419	0·083	0·539	0·180	0·489	0·140	0·221 2	0·228 9	0·213 9	23
0·355	0·004	0·479	0·100	0·459	0·083	0·579	0·180	0·529	0·140	0·174 2	0·179 7	0·168 9	23
0·400	0·005	0·525	0·100	0·505	0·083	0·625	0·180	0·575	0·140	0·137 2	0·141 9	0·132 7	24
0·450	0·005	0·585	0·110	0·565	0·090	0·695	0·200	0·635	0·150	0·108 4	0·111 8	0·105 1	25
0·500	0.005	0·635	0·110	0·615	0·090	0·745	0·200	0·685	0·150	0·087 81	0·090 37	0·085 34	25
0·560	0·006	0·696	0·110	0·676	0·090	0·806	0·200	0·746	0·150	0·070 00	0·721 5	0·067 94	26
0·630	0·006	0·766	0·110	0·746	0·090	0·876	0·200	0·816	0·150	0·055 31	0·056 87	0·053 81	27
0·710	0·007	0·867	0·125	0·842	0·100	0·987	0·220	0·917	0·160	0·043 55	0·044 81	0·042 34	28
0·750	0·008	0·908	0·125	0·883	0·100	1·028	0·220	0·958	0·160	0·039 03	0·040 22	0·037 88	28
0·800	0·008	0·958	0·125	0·933	0·100	1·078	0·220	0·988	0·160	0·034 30	0·035 30	0·033 34	28
0·850	0·009	1·009	0·125	0·984	0·100	1·129	0·220	1·039	0·160	0·030 38	0·031 31	0·029 50	28
0·900	0·009	1·059	0·125	1·034	0·100	1·179	0·220	1·109	0·160	0·027 10	0·027 89	0.026 34	29
0·950	0·010	1·110	0·125	1·085	0·100	1·230	0·220	1·160	0·160	0·024 32	0·025 06	0·023 62	29
1·000	0·010	1·160	0·125	1·135	0·100	1·280	0·220	1·216	0·160	0·021 95	0·022 59	0·021 34	30
1·060	0·011	1·221	0·125	1·196	0·100	1·341	0·220	1·271	0·160	0·019 54	—	—	30
1·120	0·011	1·291	0·135	1·266	0·110	1·421	0·240	1·351	0·180	0·017 50	—	—	30
1·180	0·012	1·352	0·135	1·327	0·110	1·482	0·240	1·412	0·180	0·015 77	—	—	31

1·250	0·013	1·423	0·135	1·398	0·110	1·553	0·240	1·483	0·180	0·014 05	—	—	31
1·320	0·013	1·493	0·135	1·468	0·110	1·623	0·240	1·553	0·180	0·012 60	—	—	32
1·400	0·014	1·574	0·135	1·549	0·110	1·704	0·240	1·634	0·180	0·011 20	—	—	32
1·500	0·015	1·675	0·135	1·650	0·110	1·805	0·240	1·735	0·180	0·009 757	—	—	32
1·600	0·016	1·791	0·145	1·761	0·120	1·926	0·260	1·856	0·200	0·008 575	—	—	32
1·700	0·017	1·892	0·145	1·892	0·120	2·027	0·260	1·957	0·200	0.007 596	—	—	32
1·800	0·018	1·993	0·145	1·993	0·120	2·128	0·260	2·058	0·200	0·006 775	—	—	32
1·900	0·019	2·094	0·145	2·064	0·120	2·229	0·260	2·159	0·200	0·006 081	—	—	32
2·000	0·020	2·195	0·145	2·165	0·120	2·330	0·260	2·260	0·200	0·005 488	—	—	33
2·120	0·021	2·316	0·145	2.286	0·120	2·451	0·260	2·381	0·200	0·004 884	—	—	33
2·240	0·022	2·452	0·160	2·427	0·130	2·592	0·280	2·522	0·220	0·004 375	—	—	33
2·360	0·024	2·574	0·160	2·544	0·130	2·714	0·280	2·644	0·220	0·003 941	—	—	33
2·500	0·025	2·715	0·160	2·685	0·130	2·855	0·280	2·785	0·220	0·003 512	—	—	33
2·650	0·027	2·867	0·160	2·837	0·130	3·007	0·280	2·937	0·220	0·003 126	—	—	34
2·800	0·028	3·018	0·160	2·988	0·130	3·158	0·280	3·088	0·220	0·002 800	—	—	34
3·000	0·030	3·220	0·160	3·190	0·130	3·360	0·280	3·290	0·220	0·002 439	—	—	34
3·150	0·032	3·372	0·160	3·542	0·130	3·512	0·280	3·442	0·220	0·002 212	—	—	34
3·350	0·034	3·584	0·170	3·554	0·140	3·734	0·300	3·654	0·230	0·001 956	—	—	34
3.550	0·036	3·786	0·170	3·756	0·140	3·936	0·300	3·856	0·230	0·001 742	—	—	35
3·750	0·038	3·988	0·170	3·958	0·140	4·138	0·300	4·058	0·230	0·001 561	—	—	35
4.000	0·040	4·240	0·170	4·210	0·140	4·390	0·300	4·310	0·230	0·001 372	—	—	35
4·250	0·043	4·493	0·170	4·463	0·140	4·643	0·300	4·563	0·230	0·001 215	—	—	35
4·500	0·045	4·745	0·170	4·715	0·140	4·895	0·300	4·815	0·230	0·001 084	—	—	36
4·750	0·048	4·998	0·170	4·968	0·140	5·148	0·300	4·068	0·230	0·000 973 0	—	—	36
5·000	0·050	5·250	0·170	5·220	0·140	5·400	0·300	5·320	0·230	0·000 878 1	—	—	36

6. COTTON

6.1 Quality — The cotton yarn shall be tested in accordance with IS : 3567-1966* before application on the conductor.

7. APPLICATION OF COTTON COVERING

7.1 General — The conductor shall be completely and uniformly covered with one or two layers of cotton, as may be required.

7.2 Arrangement of Layers — The cotton covering shall be lapped firmly, evenly, closely and continuously round the conductor. Where there are two layers, they shall be applied in opposite directions.

8. OVERALL DIAMETER AND INCREASE IN DIAMETER

8.1 The maximum overall diameter and the minimum increase in diameter shall be in accordance with Table 1.

8.2 Measuring Equipment — The measurement shall be made with an accuracy better than 0·002 mm. If a micrometer is used it shall be ensured that the measuring force is in the range of 0·75 to 1·25 N. The spindle and the anvil of the micrometer shall have a diameter of 5 to 8 mm.

For wires greater than 0·500 mm, a force of 1 to 3 N may be used.

8.3 Measuring Method

8.3.1 *Overall Diameter of the Wire* — Approximately 1·5 m length of the wire from the reel shall be discarded and the diameter determined over the covering. Three measurements at 60° angular displacement shall be made around the circumference of the wire at each of the two places one metre apart.

The average of the six results shall be reported as 'overall diameter'.

8.3.2 *Conductor Diameter* — The covering shall be removed at two places one metre apart.

Three measurements at 60° angular displacement shall be made around the circumference of the conductor at these places.

The average of the six results for the bare diameter shall be reported as 'conductor diameter'.

8.3.3 *Increase in Diameter* — The difference between the overall diameter and the conductor diameter is the 'increase in diameter due to covering'.

9. MANDREL WINDING TEST

9.1 A sample of the covered wire shall be wound on a polished metal mandrel having a diameter as follows:

---

*Specification for cotton yarn for covering conductors.

Nominal Conductor Diameter (*d*)		*Mandrel Diameter*
Over	Up to and Including	
mm	mm	mm
—	1·000	6 *d*
1·000	5·000	8 *d*

9.2 Only sufficient tension shall be used to give an even and compact layer. The cotton covering shall not open sufficiently to expose the conductor or the inner layer, if any, to view, when examined under diffused light by normal eyesight.

10. PACKING AND MARKING

10.1 The wire shall be tightly and evenly wound on reels complying with IS: 482-1968*.

10.1.1 The wire on each reel shall be in one continuous length.

10.2 The label which is to be securely attached to the reel shall have the following information:

a) Manufacturer's name or trade-mark,
b) Grade of covering,
c) Nominal conductor diameter,
d) Increase in diameter due to covering, and
e) Weight of wire (gross and net).

10.3 BIS Certification Marking

The product may also be marked with Standard Mark.

10.3.1 The use of the Standard Mark is governed by the provisions of the Bureau of Indian Standards Act, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

11. SAMPLING

11.1 A recommendatory sampling plan and criteria for acceptance of lot are given in Appendix B.

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*Specification for reels for covered, round electrical winding wires (*second revision*).

APPENDIX A

(*Clause* 5.5.3)

METHOD OF CALCULATION OF LINEAR RESISTANCE

A-1. LIMITS OF ELECTRICAL RESISTANCE

A-1.1 The limits of electrical resistance are calculated on the following basis.

A-1.1.1 The maximum and minimum values of resistance for conductors of diameter up to and including 1·000 mm are calculated from the maximum and minimum dimensional tolerance.

The linear resistance is :

$$R_{\max} = \rho_{\max} q^{-1}_{\min} \text{ (ohm/m)}$$

$$R_{\min} = \rho_{\min} q^{-1}_{\max} \text{ (ohm/m)}$$

Where $q_{\max}$ and $q_{\min}$ are respectively the maximum and minimum conductor cross-section in mm^2 calculated by taking into account the relevant dimensional tolerance for the diameter.

A-1.1.2 The maximum and minimum values of resistivity are given below :

$$\rho_{\max} = 1/57{\cdot}5 \text{ (ohm.mm}^2\text{/m)}$$

$$\rho_{\min} = 1/58{\cdot}5 \text{ (ohm.mm}^2\text{/m)}$$

APPENDIX B

(*Clause* 11.1)

RECOMMENDED SAMPLING PLAN AND CRITERIA FOR ACCEPTANCE OF LOT

B-1. LOT

B-1.1 In any consignment all the reels of the same type, and manufactured from the same material under essentially similar conditions of production shall be grouped together to constitute a lot.

B-2. SCALE OF SAMPLING

B-2.1 For judging the conformity of a lot to the requirements of the specification, the tests shall be done for each lot separately. For this purpose the number of reels to be selected at random from lot shall be in accordance with Table 2.

TABLE 2 SCALE OF SAMPLING AND PERMISSIBLE NUMBER OF DEFECTIVES

(*Clause* B-2.1)

LOT SIZE	FOR PHYSICAL CONSTANTS AND DIAMETER		FOR RESISTANCE, ELONGATION AND FREEDOM FROM DEFECTS	
	Sample Size	Permissible No. of Defectives	Sample Size	Permissible No. of Defectives
(1)	(2)	(3)	(4)	(5)
Up to 300	20	0	13	0
301 to 500	32	1	20	0
501 to 1 000	50	2	32	1
1 001 to 3 000	80	3	50	2
3 001 and above	125	5	80	3

B-3. NUMBER OF TESTS AND CRITERIA FOR ACCEPTANCE

B-3.1 From each of the reels selected according to col 2 of Table 2, suitable lengths of test samples shall be taken after discarding approximately 1·5 m of the wire from both ends. Each of these test samples shall be subjected to the measurements of dimensions and physical constants (*see* **5.2** and **5.3**). The number of test samples not fulfilling the requirements of any of these tests shall be less than or equal to the corresponding permissible number given in col 3 of Table 2.

B-3.2 For the test for resistance, elongation and freedom from defects, the number of samples to be tested and the permissible number of defects for each of these characteristics shall be in accordance with col 4 and 5 of Table 2.

NOTE — The test samples for the purpose of **B-3.2** may be chosen from the reels already selected for the purpose of **B-3.1**.

B-3.3 If the requirements of **B-3.1** and **B-3.2** are met with, the lot shall be accepted.

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*Eastern : 1/14 CIT Scheme VII M, V.I.P. Road, Maniktola, CALCUTTA 700054	337 86 62
Northern : SCO 335-336, Sector 34-A, CHANDIGARH 160022	60 38 43
Southern : C.I.T. Campus, IV Cross Road, MADRAS 600113	235 23 15
†Western : Manakalaya, E9, Behind Marol Telephone Exchange, Andheri (East), MUMBAI 400093	832 92 95
Branch Offices:	
'Pushpak', Nurmohamed Shaikh Marg, Khanpur, AHMEDABAD 380001	550 13 48
‡Peenya Industrial Area, 1st Stage, Bangalore-Tumkur Road, BANGALORE 560058	839 49 55
Gangotri Complex, 5th Floor, Bhadbhada Road, T.T. Nagar, BHOPAL 462003	55 40 21
Plot No. 62-63, Unit VI, Ganga Nagar, BHUBANESHWAR 751001	40 36 27
Kalaikathir Buildings, 670 Avinashi Road, COIMBATORE 641037	21 01 41
Plot No. 43, Sector 16 A, Mathura Road, FARIDABAD 121001	8-28 88 01
Savitri Complex, 116 G.T. Road, GHAZIABAD 201001	8-71 19 96
53/5 Ward No. 29, R.G. Barua Road, 5th By-lane, GUWAHATI 781003	54 11 37
5-8-56C, L.N. Gupta Marg, Nampally Station Road, HYDERABAD 500001	20 10 83
E-52, Chitaranjan Marg, C-Scheme, JAIPUR 302001	37 29 25
117/418 B, Sarvodaya Nagar, KANPUR 208005	21 68 76
Seth Bhavan, 2nd Floor, Behind Leela Cinema, Naval Kishore Road, LUCKNOW 226001	23 89 23
Patliputra Industrial Estate, PATNA 800013	26 23 05
T.C. No. 14/1421, University P.O. Palayam, THIRUVANANTHAPURAM 695034	6 21 17
Inspection Offices (With Sale Point):	
Pushpanjali, 1st Floor, 205-A, West High Court Road, Shankar Nagar Square, NAGPUR 440010	52 51 71
Institution of Engineers (India) Building, 1332 Shivaji Nagar, PUNE 411005	32 36 35

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*Sales Office is at 5 Chowringhee Approach, P.O. Princep Street, CALCUTTA 700072	27 10 85
†Sales Office is at Novelty Chambers, Grant Road, MUMBAI 400007	309 65 28
‡Sales Office is at 'F' Block, Unity Building, Narashimaraja Square, BANGALORE 560002	222 39 71

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